NASA SPACE FACTS

101 INSIGHTS ABOUT NASA, THE SPACE INDUSTRY, AND PROFESSIONAL POSSIBILITIES

EDITED AND COMPILED BY
MICHAEL E. KELLEY AND CHANEL V. LESLIE

INTRODUCTION REMARKS BY ARTHUR STEPHENSON OF NASA
AND DELBERT BAKER OF OAKWOOD COLLEGE

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Appreciation is expressed to all source persons listed in this book.

Other titles in the 101 series produced by Oakwood College include:
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The Coping Workbook, and the *Help-Yourself ListBook*

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Administration (NASA)
and the Marshall Space Flight
Center (MSFC)

Dedicated to the memory of the Columbia Crew

The catastrophic accident of the space shuttle *Columbia* happened as the spaceship was preparing to land at the Kennedy Space Center in Florida on February 1, 2003. It had traveled 6 million miles through outer space.

INTRODUCTION: NASA

When I was director of the National Aeronautics and Space Administration (NASA)/Marshall Space Flight Center (MSFC), one of the opportunities I had was the privilege of working with several of the fine educational institutions in the Huntsville area. This approach is consistent with NASA's goal to encourage and inspire students and other interested persons to see the unlimited possibilities available to them in the space industry. One of the institutions of higher education I have had the privilege of working with is Oakwood College.

I am pleased to have participated in the concept behind the acquisition of the Oakwood College Industries facility, which houses a special collaboration between NASA/ Marshall Space Flight Center and Oakwood College. The development of this facility will provide on-the-job training to

expose young people to light industrial fabrication as one of the steps toward possibilities with NASA and the space industry.

This exciting opportunity has resulted in the origin of the Minority Explorers Program (MEP). This entire collaboration between Oakwood College and NASA has great potential that will doubtlessly bring fruit in the future.

Along with the program, I am delighted to see the development of this quote book, *Space Industry Facts: 101 Insights About NASA, the Space Industry, and Professional Possibilities.* May this book enlighten and inspire young people and all other readers as we work with Oakwood College in the development and future growth of young people and its fabrication capability.

Arthur G. Stephenson
Special Assistant to the Associate Administrator
for Education
National Space Science and Technology Center

INTRODUCTION: OAKWOOD COLLEGE

Oakwood College, a historically Black institution of higher education, is located within ten miles of Marshall Space Flight Center (MSFC), one of the major centers of the National Aeronautics and Space Administration (NASA). The college was first established in 1896, while MSFC began operations in 1960–both in Huntsville, Alabama.

Oakwood College produces dynamic and talented graduates–the majority of whom are persons of color. NASA/MSFC, especially with the current NASA strategic goals, seeks to match potential employees with exciting job opportunities in the special effort being given to attract more minority employees. Therefore, the resulting collaboration has created a fertile and beneficial relationship.

We are pleased with the new Minority Explorers Program

(MEP) that will acquaint students, faculty, staff, and constituents with research and employment opportunities in this important area. Also resulting from the NASA/MSFC collaboration is the development of a fabrication factory located in the new Oakwood College Industries building which will expose students to possibilities in the space industry. This first-of-its-kind collaboration for Oakwood College and NASA/MSFC will open up great possibilities for young people.

This book of NASA facts–put together by two talented and diverse professionals who are keenly knowledgeable of the subject matter–will help to educate and enlighten readers as to the proud history and wonderful opportunities that are available in this important area.

Oakwood College looks forward to a lasting and fruitful relationship with NASA/MSFC.

Delbert W. Baker, Ph.D.
President
Oakwood College

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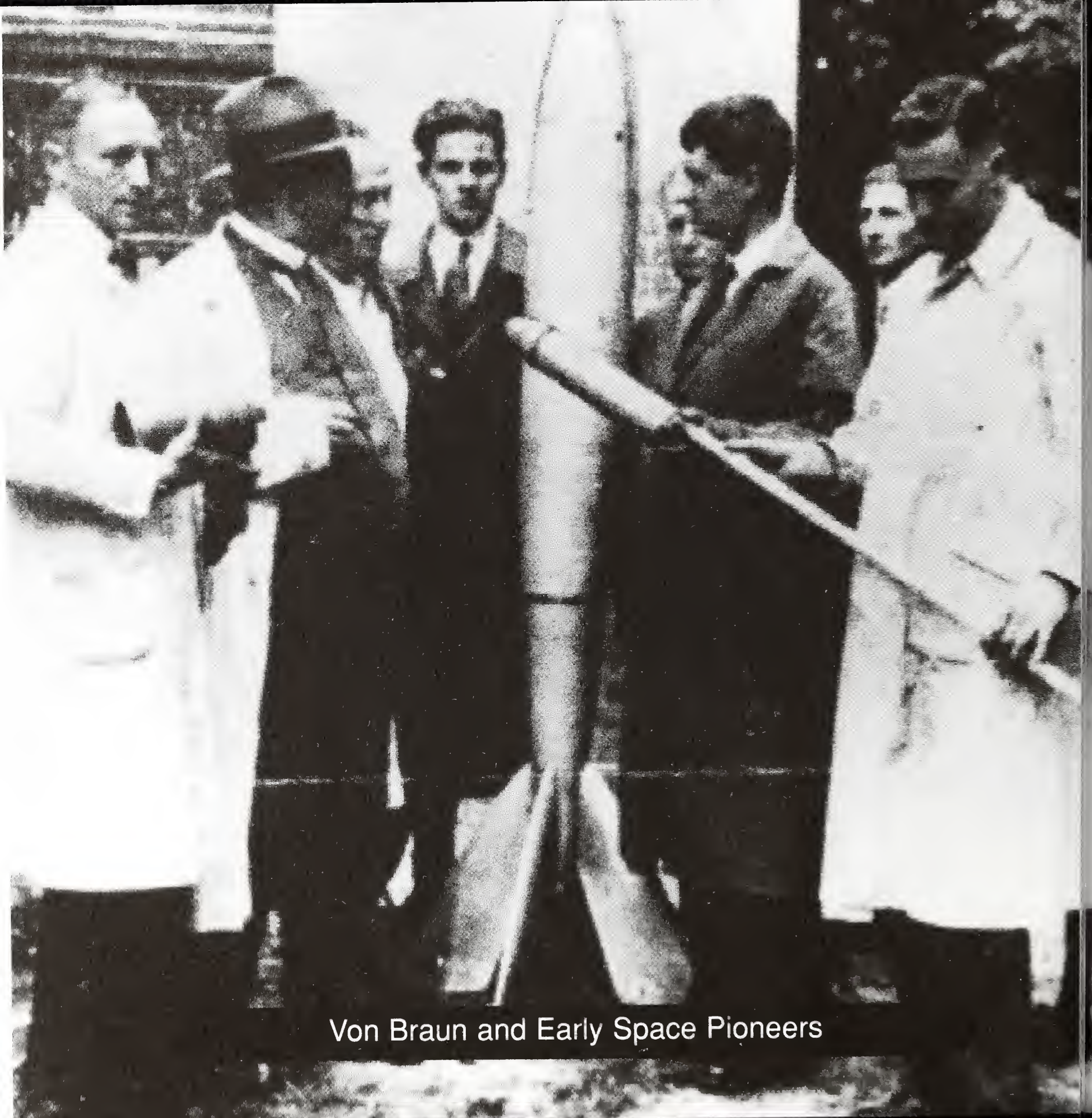
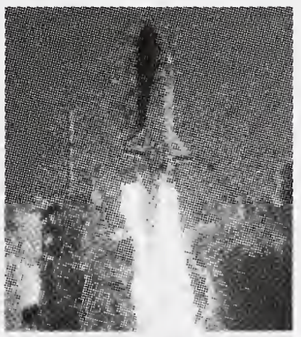


Von Braun and Early Space Pioneers

CHAPTER ONE

The 50s and 60s America Leaps into Space

NASA and Marshall Space Flight Center pulled out all stops in the 1960s to make sure that America met President John F. Kennedy's challenge to put a man on the moon by the end of the decade.



FACT #1

The Scientists Arrive

The 118 German scientists who formed the nucleus of America's space efforts in the 1950s and 1960s had surrendered to the U.S. Army in February 1945. Following their surrender, they were sent as "prisoners of peace" to the U.S. Army's rocket and missile proving ground at White Sands, New Mexico. They lived at nearby Fort Bliss, Texas, until they were sent to Huntsville, Alabama, in 1950.

Quote:

"We are all woven together in the great web of humanity, and whatever we can do to benefit and uplift others will reflect in blessing upon ourselves."

– Ellen G. White.

FACT #2

First Redstone Astronauts

Huntsville's Redstone Rocket, developed at Marshall Space Flight Center, launched the first American into space, Alan Shepard, in 1961. Later that year a Redstone Rocket launched the second American, Virgil "Gus" Grissom, into space.

Quote

Only those who dare to fail greatly can ever achieve greatly.

– Robert Kennedy, U.S. attorney general in the administration of his brother, President John F. Kennedy.

FACT #3

Booming Huntsville

The population of Huntsville, Alabama, in June 1950 was just over 16,000. The large buildup of people and resources at Redstone Arsenal during the 1950s caused the population to mushroom to more than 70,000 by 1960. By 1966, with the Saturn program in full swing, Huntsville had grown to more than 120,000 residents. A far cry from when Huntsville was known as the "watercress capital of the world."

Quote:

Every action done in company ought to be done with respect to those who are present.

– George Washington, first U.S. president.

FACT #4

An Unlikely Consolation Prize

The U.S. Army's 1949 decision to establish Redstone Arsenal as the center for rocket research was seen by Huntsville civic leaders as merely a consolation prize, since the Air Force's research and development position went to Tullahoma, Tennessee. But within a decade, Redstone Arsenal commanded a far larger budget and workforce than Arnold Engineering and Development Center at Tullahoma ever would.

Quote:

Only those who dare to fail greatly
can ever achieve greatly.

– Robert Kennedy.

FACT #5

Civilian Control of Space Efforts

The National Aeronautics and Space Administration (NASA) was established in 1958 so that a civilian agency would be in charge of the peaceful exploration of space. Earlier U.S. efforts in space exploration had been conducted by the Army, Air Force, and Navy.

Quote:

Whatever America hopes to bring to pass in the world must first come to pass in the heart of America.

– Dwight D. Eisenhower, thirty-fourth U.S. president.

FACT #6

1960: It Becomes Official

When NASA was created in 1958, Marshall Space Flight Center was not originally a part of it. The 4,000 government employees and 1,800 acres of land that comprised Marshall Space Flight Center did not become part of NASA until July 1960.

Quote:

When a thing is done, it's done. Don't look back. Look forward to your next objective.

– General George C. Marshall.

FACT #7

Marshall: A General's Name

Marshall Space Flight Center is named after General George C. Marshall, U.S. Army chief of staff during World War II. As secretary of state during the Truman administration, Marshall initiated the Marshall Plan under which billions of dollars were spent to help rebuild a war-shattered Europe following World War II.

Quote:

If man does find the solution for world peace it will be the most revolutionary reversal of his record we have ever known.

– General George C. Marshall.

FACT #8

America's First Satellite

America's first satellite, Explorer I, was launched into orbit on January 31, 1958, on a Jupiter-C rocket developed at Redstone Arsenal after an earlier attempt by a Navy Viking rocket failed.

Quote:

Don't fight the problem, decide it.

– General George C. Marshall.

FACT #9

Kennedy Sets a Goal

U.S. president John F. Kennedy electrified the nation when he declared in May 1961 that America should make it a national goal to put a man on the moon within the decade. That goal was accomplished in July 1969 when astronaut Neil Armstrong set foot on the lunar surface.

Quote:

It should be the goal of this nation by the end of this decade to put a man on the moon and return him safely to Earth.

– John F. Kennedy, thirty-fifth U.S. president.

FACT #10

Von Braun and Tomorrowland

Dr. Wernher von Braun worked with Walt Disney in the mid 1950s to develop Disney's Tomorrowland series of television programs about space. This TV series did much to raise America's interest in space travel and exploration, and helped set the stage for the 1960s effort to put a man on the moon.

Quote:

For my confirmation, I didn't get a watch and my first pair of long pants, like most Lutheran boys. I got a telescope. My mother thought it would make the best gift.

– Wernher von Braun, first MSFC director and leader of U.S. space efforts, 1950-1975.

FACT #11

The First Giant Rocket

One of Marshall Space Flight Center's first projects was development of the Saturn I, a giant rocket using a cluster of liquid–fueled engines producing a total of 1.5 million pounds of thrust, which was first launched in 1961. A later, more powerful version, the Saturn I-B, launched several three-man Apollo missions into earth orbit.

Quote:

I have learned to use the word "impossible" with the greatest caution.

– Wernher von Braun.

FACT #12

The Mighty Saturn

The largest launch vehicle ever produced by the United States was the Saturn V, whose development was managed by the Marshall Space Flight Center. Standing more than 300 feet tall and weighing over 6 million pounds at launch, it had the power needed to move the Apollo capsule, lunar lander, and service module to over 24,000 miles per hour—fast enough to escape Earth's gravity.

Quote:

Space travel will free man from the remaining chains, the chains of gravity which still tie him to this planet.

– Wernher von Braun.

FACT #13

A Blazing Inferno

Each of the five F-1 engines in the Saturn V's first stage developed 1.5 million pounds of thrust. Each engine consumed two tons of kerosene fuel and one ton of liquid oxygen for each second of its two-minute burn. Temperatures in the combustion chamber reached more than 5,000 degrees.

Quote:

Our sun is one of 100 billion stars in our galaxy. Our galaxy is one of billions of galaxies populating the universe. It would be the height of presumption to think that we are the only living things in that enormous immensity.

– Wernher von Braun.

FACT #14

Like a Small Earthquake

Marshall Space Flight Center's test firings of the Saturn V first stage had the effect of small earthquakes, shaking and vibrating buildings in downtown Huntsville and as far away as Decatur. The New York Times, Washington Post, and other major national media sent reporters to cover the events.

Quote:

Somewhere, something incredible is waiting to be known.

– Carl Sagan, U.S. physicist and space writer.

FACT #15

Alabama's Tallest Building

At 360 feet in height, Marshall's dynamic test stand was for several years the tallest building in Alabama. Designed to simulate the stresses of launch, it was used to subject the Saturn V, and later the space shuttle, to stresses and vibrations at more than 800 points.

Quote:

If you fear making anyone mad, then you ultimately probe for the lowest common denominator of human achievement.

– Jimmy Carter, thirty-ninth U.S. president.

FACT #16

An Army of Employees

At the height of the Saturn development program in 1965, more than 7,000 civil service employees and 15,000 contractor employees worked at the Marshall Space Flight Center, more than triple the number of MSFC employees in 2003.

Quote:

If we all worked on the assumption that what is accepted as true is really true, there would be little hope of advancement.

– Orville Wright, early flight pioneer.

FACT #17

A Lunar Rover

Marshall's engineers and technicians developed the Lunar Rover, the vehicle designed for astronauts to drive on the moon's surface, in a short 17 months. At that time, in the late 1960s, it took Ford or General Motors two years or more to develop a new automobile model.

Quote:

Houston, this is Apollo 10. You can tell the world we have arrived.

– Thomas P. Stafford, astronaut on first circumlunar mission, 1969.

FACT #18

A Man on the Moon

President Kennedy's stated U.S. goal of putting a man on the moon by the end of the decade was achieved on July 16, 1969, when astronaut Neil Armstrong stepped off the lunar lander onto lunar soil. It was truly a momentous day for the United States and the world.

Quote:

In a very real sense, it will not be one man going to the moon . . . it will be an entire nation. For all of us must work to put him there.

– John F. Kennedy, May 1961.

FACT #19

One Small Step for Mankind

Some of the most famous words uttered in modern history were those of astronaut Neil Armstrong as he stepped onto the moon.

Quote:

That's one small step for a man,
one giant leap for mankind.

– Neil Armstrong, U.S. astronaut, first man on the moon.

FACT #20

The Orbiting Workshop

Skylab, the "orbital workshop" program that succeeded Saturn/Apollo, was jointly managed by Marshall Space Flight Center and Houston's Manned Spacecraft Center. To save money, NASA converted a Saturn third stage into an orbiting laboratory complete with work, study, and recreation areas.

Quote:

For man there is no rest and no ending. He must go on conquests beyond conquests; and when he has conquered all the depths of space and all the mysteries of time, still he will be beginning.

– H. G. Wells, science fiction writer.

FACT #21

Water to Simulate Space

Marshall's Neutral Buoyancy Simulator, built to simulate weightless conditions of space, was used extensively in astronaut training. Essentially a huge tank, it was 75 feet in diameter and 40 feet deep, and held 1.5 million gallons of water.

Quote:

Explorations have to be inspired and triggered by a leader, but they have to meet with the acceptance and the enthusiasm of the crowd.

– Jacques Cousteau, French undersea explorer.

FACT #22

The Orbiting Telescope

A major feature of the Skylab scientific missions was the Apollo Telescope Mount (ATM), the largest and most sophisticated scientific payload ever developed entirely at Marshall Space Flight Center. Orbiting at 270 miles above the earth, the eight telescopes in the ATM could observe the sun free of the distortion and haze caused by Earth's atmosphere.

Quote:

I have never met a man so ignorant that I couldn't learn something from him.

– Galileo, sixteenth-century
Italian astronomer.

FACT #23

A Daring Rescue

One of the most dramatic rescues in American history was the rescue of Skylab 1, launched in May 1973. During launch, the spacecraft's micrometeroid shield became detached, allowing temperatures inside the spacecraft to rise to more than 200 degrees. Astronauts of Skylab 2, launched 11 days later, were able to erect a solar reflecting sail on the orbiting laboratory, which returned temperatures to normal and allowed the mission to continue.

Quote:

My view of our planet was a glimpse of divinity.

– Edgar Mitchell, astronaut.

FACT #24

High School Science in Space

The Skylab missions provided the first opportunity for American high school science students to design experiments to be performed in space. One of the most interesting was a study of how spiders formed webs in the absence of gravity.

Quote:

Mystery creates wonder and wonder is the basis of man's desire to understand.

– Neil Armstrong.

FACT #25

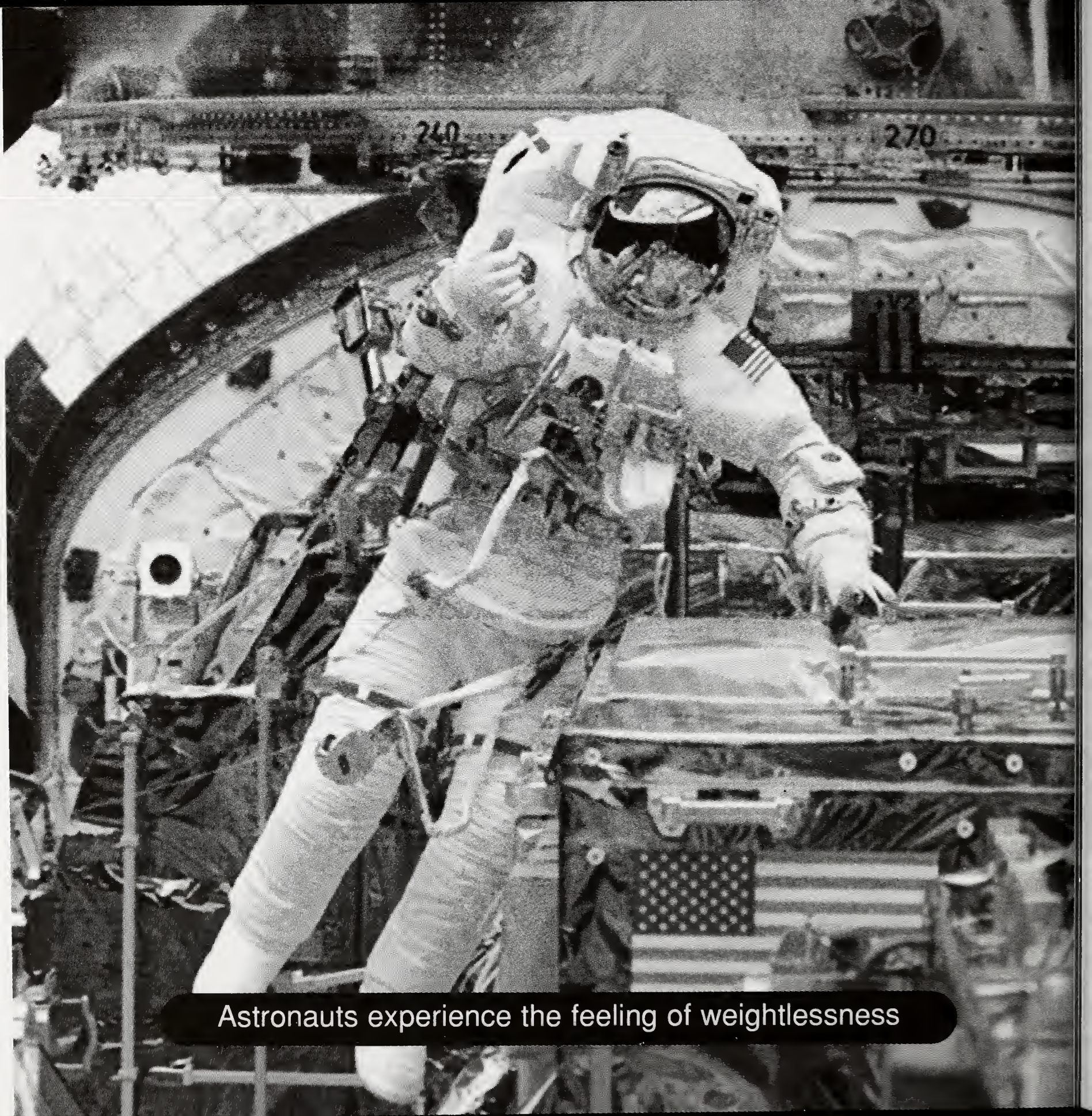
PROJECT HIGHWATER

One of the earliest NASA scientific experiments was Project Highwater, in which 86 tons of water were launched and released into the upper atmosphere aboard a Saturn I in 1962. Ridiculed by many as a waste of money, the experiment nonetheless provided much new knowledge about cloud formation and molecular dispersion in the upper atmosphere.

Quote:

Imagination will often carry us to worlds that never were. But without it we go nowhere.

– Carl Sagan.

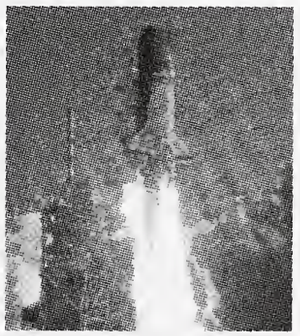


Astronauts experience the feeling of weightlessness

CHAPTER TWO

The 70s:
Science Takes the Forefront

With the race to the moon achieved, NASA and Marshall Space Flight Center turned their attention to the exploration of space around the earth. Skylab, Apollo-Soyuz, and other programs probed "near space," and told us much about the world around our world.



FACT #26

A Little Monkey Business

Before NASA put a man in space, it put two monkeys in space. Able and Baker flew aboard a Jupiter rocket in May 1959 on a 10,000-mile suborbital flight. Baker became known as the "first lady in space." Somewhat of a celebrity, she lived out the rest of her life at Huntsville's U.S. Space and Rocket Center.

Quote:

Wherever life takes us, there are always moments of wonder.

– Jimmy Carter.

FACT #27

Recycling Saturn

In order to save money, NASA developed Skylab, America's first orbiting laboratory, from a Saturn S-IVB third stage. Skylab had areas for astronauts to live, work, and sleep for extended space missions.

Quote:

The most valuable of all talents is that of never using two words when one will do.

– Thomas Jefferson, third U.S. president.

FACT #28

A Huge Laboratory

Skylab weighed in at nearly 100 tons. Although a converted Saturn V was able to put Skylab into orbit, it required a second launch to put into orbit the astronauts who would live aboard Skylab.

Quote:

It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow.

– Robert H. Goddard, U.S. rocketry pioneer.

FACT #29

An Odd House

With a diameter of 21 feet and a length of more than 60 feet, Skylab had about as much living space as a small three-bedroom home. But it was a very unusual house: a former liquid oxygen tank became living quarters, while the liquid hydrogen tank became a waste disposal system.

Quote:

The opportunities of this age are their own inspiration.

– Hugh Dryden, early NASA official.

FACT #30

STROLLS IN SPACE

Skylab provided the first opportunity for extended space walks. From unloading film canisters on the Apollo Telescope Mount to repairing the orbiter, astronauts accumulated more than 20 hours floating in space.

Quote:

My view of our planet was a glimpse of divinity.

– Edgar Mitchell.

FACT #31

Skylab: A Big Eye and A Big Ear

Skylab, the orbital workshop, was the first laboratory in space. Equipped with telescopes on the outside and radio/TV transmitting equipment inside, it gathered a tremendous amount of knowledge about our universe, which was transmitted immediately to Earth.

Quote:

The science of today is the technology of tomorrow.

– Edward Teller, U.S. scientist.

FACT #32

SKYLAB: RADIATION SENSOR

Operating nearly 200 miles above the earth, Skylab was able to detect for the first time ultraviolet and X-ray radiation not detectable on the ground.

Quote:

I don't know what you could say about a day in which you have seen four beautiful sunsets.

– John Glenn, U.S. astronaut.

FACT #33

Skylab: The Earth Monitor

Skylab's orbit was set so that it would pass over 75 percent of the earth's surface, and cover each point every five days. This provided a tremendous research opportunity for scientists wanting to study geologic and other features of our planet's surface.

Quote:

From space, the world itself looks cleaner and so much more beautiful. Maybe we can make it that way, the way God intended it to be, by giving everyone that new perspective from space.

– Roger Chaffee, U.S. astronaut.

FACT #34

SKYLAB: HUMAN FUNCTIONS IN SPACE

The three Skylab missions featured extensive monitoring of human biomedical and physiological conditions to study how the human body functions under extended periods of weightlessness. These experiments studied sleep, digestion, respiration, cardiovascular functions—virtually every aspect of human activity.

Quote:

The upward course of a nation's history is due in the long run to the soundness of heart of its average men and women.

– Queen Elizabeth II.

FACT #35

Studying Solar Flares

Among the most fascinating areas of study aboard Skylab were solar flare phenomena. In conjunction with scientists at the University of Colorado's High Altitude Observatory, Marshall scientists advanced the baseline of understanding of solar flares, sunspots, and other events for the next decade.

Quote:

An outlook through this peephole [of manned space flight] at the vast mysteries of the universe should only confirm our belief in the certainty of its Creator.

– Wernher von Braun.

FACT #36

Materials in a Weightless Environment

Skylab's Material Processing Facility included a number of experiments dealing with properties of materials in a weightless environment. The orbiting laboratory featured a combustion chamber, a freeze solidification furnace, and an electron beam welding device.

Quote:

I have not failed. I've just found 10,000 ways that won't work.

– Thomas A. Edison, American inventor.

FACT #37

Apollo-Soyuz

NASA's first joint space mission with another nation was the 1975 Apollo-Soyuz mission with Russia. The mission called for the docking in space of a Soviet Soyuz and an American Apollo craft. Apollo-Soyuz helped create the atmosphere for the eventual thawing of Soviet-American relations.

Quote:

The things that we share in our world are far more valuable than those which divide us.

– Donald Williams, U.S. astronaut.

FACT #38

Stuhlinger's Brainchild

NASA's High Energy Astronomy Observatory (HEAO) began as the brainchild of Dr. Ernst Stuhlinger, head of Marshall's Research Projects Laboratory. One of the 118 scientists and engineers who came with Wernher von Braun to Huntsville in 1950, Dr. Stuhlinger was still living in Huntsville in 2004. NASA planned three HEAO missions, which were launched between 1977 and 1979.

Quote:

The value of a man resides in what he gives and not in what he is capable of receiving.

– Albert Einstein, American physicist.

FACT #39

HEAO's Discoveries

HEAO missions gave the world its first images of high-altitude radiation sources and discovered thousands of new supernovas, cosmic rays, black holes, pulsars, quasars, and dwarf stars.

Quote:

History tells us that it pays in unexpected ways to attempt to satisfy our curiosity about the universe.

– Dr. Eberhard Rees, second director, Marshall Space Flight Center.

FACT #40

Marshall Leads in Microgravity

By the end of the 1970s, Marshall scientists had taken the lead in NASA's microgravity research, working with universities and corporations across the United States. It was felt that materials processing in the absence of gravity would lead to new materials, improvements in electronics and medical devices, and new manufacturing processes.

Quote:

When one door closes another door opens; but we so often look so long and so regretfully upon the closed door, that we do not see the ones which open for us.

– Alexander Graham Bell, inventor of the telephone.

FACT #41

Marshall Works the Mines

One of Marshall's most unusual programs was its assistance to the U.S. Bureau of Mines. Using space-derived technologies, Marshall engineers discovered ways to improve the efficiency of long-wall shearing machines used in coal mining. So effective were the results, MSFC was lauded for its efforts by the U.S. Department of Energy.

Quote:

Sometimes the first duty of intelligent men is the restatement of the obvious.

– George Orwell, U.S. author.

FACT #42

MARSHALL AND SOLAR HEATING

MSFC contributed greatly to solar heating research in the mid-1970s. As the lead NASA center for research under the 1974 Solar Energy Heating and Cooling Demonstration Act, Marshall conducted research that helped dramatically cut the cost to consumers of solar heating and cooling systems.

Quote:

When you do the common things in life in an uncommon way, you will command the attention of the world.

– George Washington Carver,
American scientist.

FACT #43

MARSHALL RESCUES LAGEOS

After budget cutbacks almost forced NASA to cancel the project, MSFC rescued the Laser Geodynamic Satellite (LAGEOS) project in 1975 by developing a scaled-down version of the original four-ton satellite. A "cannonball in space," LAGEOS is a 24-inch brass sphere covered with silica reflectors, weighing nearly 900 pounds. It is estimated LAGEOS will stay in orbit for about 8 million years.

Quote:

We have to do the best we can. This is our sacred human responsibility.

– Albert Einstein.

FACT #44

MICROGRAVITY EXPERIMENTS

NASA's research into microgravity, the realm of near-weightlessness, began with Skylab 1. Marshall scientists and engineers pushed to include microgravity experiments on the first Skylab mission in May 1973. Skylab astronauts experimented with growing pure crystals for electronics use and producing metals from various alloys.

Quote:

Life is a culmination of the past, an awareness of the present, an indication of a future beyond knowledge, the quality that gives a touch of divinity to matter.

– Charles Lindbergh, American pilot and first man to fly solo across the Atlantic Ocean, 1927.

FACT #45

Saving Money: The Drop Tube

Responding to NASA budget restraints in the 1970s, Marshall engineers devised other ways to conduct weightlessness experiments. A drop tube inside the existing Dynamic Test Stand provided three seconds of weightlessness, while an aircraft flying a parabolic pattern could provide up to 30 seconds of weightless conditions.

Quote:

Life is a culmination of the past, an awareness of the present, an indication of a future beyond knowledge, the quality that gives a touch of divinity to matter.

– Charles Lindbergh.

FACT #46

Saving Money: The SPAR Project

In 1975, Marshall conducted further microgravity research with the Space Processing Applications Rockets (SPAR), low-cost rockets fired into suborbital flights. Up to nine microgravity experiments could be conducted during the five-minute return to Earth.

Quote:

Everything comes to him who hustles while he waits.

– Thomas Edison.

FACT #47

SPACELAB: A NASA-ESA COLLABORATION

In the first major collaboration with a non-U.S. space agency, NASA and the European Space Agency (ESA) teamed up in the early 1980s to produce Spacelab, a totally self-contained scientific laboratory. It also marked the first occasion for Marshall scientists to direct scientific experiments flown on a U.S. spacecraft.

Quote:

Exploration is really the essence of the human spirit.

– Frank Borman, U.S. astronaut.

FACT #48

Garriott: Huntsville's Astronaut

Astronaut Owen Garriott directed the 72 experiments conducted on Spacelab 1, the only astronaut to have flown on two of the three Skylab missions Garriott was one of only two astronauts living in Huntsville in 2004.

Quote:

Skylab added so much to our knowledge of the earth as well as the space around us.

– Owen Garriott.

FACT #49

Spacelab: The Space Superlaboratory

Spacelab 1 carried 40 scientific devices (far more than Skylab) used in five different areas of experimentation: astronomy and solar physics, material sciences, space plasma physics, atmospheric physics, and Earth observation.

Quote:

We are just probing the surface of the greatest advancement in man's knowledge of his surroundings that has ever been made.

– John Glenn, first U.S. astronaut to orbit the earth.

FACT #50

SPACELAB: ALMOST LIKE HOME

Spacelab was the first orbiting spacecraft devoted to scientists. For the first time, scientists could work in space, using standard scientific instruments in a shirt-sleeve environment.

Quote:

If I have seen farther than most men, it is because I have stood on the shoulders of giants.

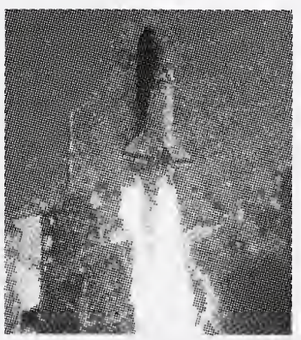
– Sir Isaac Newton.

Skylab on first of three missions

CHAPTER THREE

The 80s and 90s: Space Shuttle and Space Station

Scientific exploration of space required the means to conduct extended experiments and for humans to live longer periods in space. The space shuttle, developed by 1981, provided that capability. Now humans could stay in space for weeks at a time.



FACT #51

Space Shuttle: The NASA Workhorse

The space shuttle, largely managed by the Marshall Space Flight Center, is NASA's longest-running space program. Design and development began in the late 1960s, and the first manned mission flew in April 1981.

Quote:

Is he alone who has courage on his right hand and faith on his left hand?

– Charles Lindbergh.

FACT #52

Early Shuttle Concepts

The Future Projects Office at the Marshall Space Flight Center issued a request for proposals as early as 1961 for a winged, reusable launch vehicle of the type that would eventually become the space shuttle. These very early ideas were based on spacecraft configured so they could take off and land like airplanes.

Quote:

I confess that in 1901 I said to my brother, Orville, that man would not fly for fifty years.

– Wilbur Wright.

FACT #53

Origin of the Name

The "space shuttle" designation for the reusable manned space vehicle originated with NASA's Dr. George Mueller, who said that NASA needed "a vehicle similar to a shuttle bus." The name stuck, and the project was so named from about 1972 onward.

Quote:

It is the greatest shot of adrenaline to be doing what you have wanted to do so badly. You almost feel like you could fly without the plane.

– Charles Lindbergh.

FACT #54

Von Braun Urges Shuttle Funding

When Dr. Wernher von Braun became NASA's associate administrator in 1970, he was influential in persuading Congress and the Nixon Administration to appropriate the funds needed for full-scale space shuttle development and deployment.

Quote:

Any man worth his salt will stick up for what he believes is right, but it takes a slightly better man to acknowledge instantly and without reservation that he is in error.

– Andrew Jackson, seventh U.S. president.

FACT #55

The Decision to go Partly Reusable

1972 marked the last Saturn/Apollo mission and the actual beginning of the shuttle development program. Operating with a much-reduced budget in the early 1970s, NASA abandoned the idea of a fully reusable shuttle, opting instead for a partially reusable vehicle, with a reusable orbiter and solid rocket boosters, but an expendable external fuel tank.

Quote:

In my own view, the important achievement of Apollo was a demonstration that humanity is not forever chained to this planet, and our visions go rather further than that, and our opportunities are unlimited.

– Neil Armstrong.

FACT #56

Like Huge Roman Candles

The solid rocket boosters that provide the punch needed to propel the shuttle to over 1,000 miles per hour before being jettisoned use a mixture of fuel and oxidizer, much like huge Roman candles. The Air Force's Minuteman missile, which predated the space shuttle by more than a decade, used a similar fuel.

Quote:

The space program is a symbol of the insatiable curiosity of all mankind to explore the unknown.

– Edwin Aldrin, U.S. astronaut.

FACT #57

The Reusable SSME

In performance and durability, the space shuttle's main engines surpass anything NASA has ever previously attempted. Each engine produces 470,000 pounds of thrust for more than eight minutes per shuttle flight. The engines can be used more than 50 times each, unlike Saturn engines, which were designed for one-time use.

Quote:

This is the world's greatest flying machine.

– John Young, U.S. astronaut.

FACT #58

SSME: Special Bearings

Space shuttle main engines operate at temperatures so high that metal bearings cannot be used. Marshall engineers developed special ceramic bearings made of silicon nitride that can withstand sustained bearing temperatures of more than 1,700 degrees.

Quote:

We venture into measureless space for the benefit of all mankind.

– Anonymous.

FACT #59

MARSHALL MANAGES SSME DEVELOPMENT

Marshall managers and engineers managed the development of the solid rocket boosters, becoming, in effect, the main contractor for this crucial program. When NASA later tallied the total cost of the SRB program, it was found that this decision shortened development time while saving millions of U.S. taxpayer dollars.

Quote:

The moon is simply the first milestone on the way to the stars.

– Arthur C. Clarke, author
2001 – A Space Odyssey

FACT #60

The Super Insulated External Tank

The space shuttle's giant external tank is more than 150 feet long and 27 feet wide. The special foam insulation covering the tank must maintain more than 250,000 pounds of liquid hydrogen fuel at -423° F, and more than 1 million pounds of liquid oxygen at a temperature of -297° F.

Quote:

"Houston, this is Apollo 10. You can tell the world we have arrived."

– Thomas P. Stafford, astronaut on first circumlunar mission, 1969.

FACT #61

The Shuttle Makes its Debut

The completed space shuttle made its debut at Marshall Space Flight Center, when on March 13, 1978, the *Enterprise* traveled slowly down Rideout Road, watched by thousands of Marshall employees. *Enterprise* caught the attention of the world, with media representatives from around the globe in Huntsville to record the event.

Quote:

There is only one objective for the space shuttle, to provide a low-cost, economical space transportation system.

– George Low, former NASA deputy administrator.

FACT #62

SHUTTLE: THE SPACE TRUCK

In the first twenty years after its first manned flight in April 1981, the space shuttle has carried more than 200 tons of material into orbit. Scientific missions such as the SpaceLab in the mid-1980s, as well as the Hubble Space Telescope launch of 1990 and the Chandra X-ray telescope launch of 1999, were all lifted to orbit on the space shuttle.

Quote:

Perhaps it won't matter, in the end, which country is the sower of the seed of exploration. The importance will be in the growth of the new plant of progress and in the fruits it will bear....The plant: the tree of human destiny.

– Neil Armstrong.

FACT #63

After Challenger: Improvements

During the two-year suspension of the shuttle program following the January 1986 *Challenger* accident, Marshall engineers and technicians not only fixed the O-ring problem with the solid rocket boosters, but made hundreds of other improvements to the shuttle's main engines and external tank.

Quote:

They had that special grace, that special spirit that says, "Give me a challenge and I'll meet it with joy."

– Ronald Reagan, fortieth U.S. president, about the deaths of the seven *Challenger* astronauts, January 1986.

FACT #64

SEPTEMBER 1988: BACK IN THE GAME

The successful flight of the orbiter *Discovery* on September 29, 1988, marked Marshall's re-entry into manned space flight and the successful resumption of the shuttle program. The launch was flawless, and the mission of STS-26 proceeded as a nearly complete success.

Quote:

We see space travel as a continuing process with countless goals, but no final end.

– Arthur C. Clark.

FACT #65

Space Shuttle: An Idea from the 50s

Americans became acquainted with the space shuttle and space station ideas back in 1952 when *Colliers* magazine published a series of illustrated articles on space exploration. In that series, Dr. Wernher von Braun envisioned a logistics vehicle to supply a huge orbiting space station. While the space shuttle became reality by 1981, the space station did not take shape until the late 1990s.

Quote:

There is only one earth. It is a tiny, precious stone. Let us treasure it; there is not another one.

– Michael Collins, U.S. astronaut.

FACT #66

The Rotating Wheel in Space

Dr. Wernher von Braun gave the world its first idea of how a space station might look. His 1952 *Colliers* series envisioned the space station as a wheel 250 feet in diameter, rotating in space to produce artificial gravity. This was for decades the space station image fixed in American minds.

Quote:

We've embarked on a new step in the evolution of man. For the first time, life will leave its planetary cradle, and . . . man will no longer be confined to those familiar continents we have known for so long.

– Wernher von Braun.

FACT #67

Shuttle: Space Station Supplier

NASA's original idea for the space shuttle was a reusable spacecraft that would ferry people, equipment, and supplies to and from the space station. Today's space shuttle acts as a space station supply ship, and has actually carried into orbit components used in building the space station.

Quote:

As we build for the future, we must find less costly and complicated ways to transport payloads into space. Such a capability . . . can be a major benefit to our space program.

–Richard Nixon, thirty-seventh U.S. president, who made the decision for development of the shuttle.

FACT #68

A Long Track Record

Marshall Space Flight Center has perhaps a longer involvement with the International Space Station than any other NASA center. Marshall's Program Development Center, under the direction of Dr. William Lucas, had worked on space station development plans as far back as the mid-1970s.

Quote:

The United States should proceed . . . with the development of an entirely new space transportation system designed to make space easily accessible to humans of the 1980s and 1990s.

– Richard Nixon.

FACT #69

Reagan Gives the Go-Ahead

Just as President John F. Kennedy used his State of the Union address in 1961 to announce the Saturn/Apollo program, President Ronald Reagan gave the go-ahead to the space station in his 1984 State of the Union address.

Quote:

I have therefore directed NASA to proceed to develop a permanently manned space station, and do it within a decade.

– Ronald Reagan.

FACT #70

The Modern Space Station

Today's International Space Station bears little resemblance to Von Braun's wheel floating in space. Approximately 60 percent completed by early 2004, the International Space Station is a cluster of modules for habitat, operations, and utility, fastened together on three axes.

Quote:

Never interrupt someone doing what you said couldn't be done.

– Amelia Earhart, woman aviation pioneer.

FACT #71

Hubble: Largest Telescope Ever

The Hubble Space Telescope, the largest optical telescope ever launched into space, measured 43 feet long by 14 feet in diameter. The main mirror, 94 inches in diameter, took more than two years to polish. It can detect light from the far reaches of the universe, seeing stars many thousands of light years away that are invisible to Earth's largest telescopes.

Quote:

Take time to deliberate; but when the time for action arrives, stop thinking and go in.

– Andrew Jackson, seventh U.S. president

FACT #72

Hubble: Extraordinary Accuracy

The accuracy of the Hubble Space Telescope is extraordinary, less than 0.1 arc second. This is comparable to a telescope in Los Angeles focusing, without straying, on a traffic light in San Francisco.

Quote:

Be courageous! Have faith! Go forward!

– Thomas A. Edison.

FACT #73

Chandra Gets Its Name

One of the most fascinating programs ever managed at Marshall was the Chandra X-ray telescope, named after the Indian-American astrophysicist Subrahmanyan Chandranekhar. Designed to detect faint pulsars and X-rays from the deepest parts of space, it was so powerful that it could read a newspaper from more than a half-mile away.

Quote:

Few men during their lifetime come anywhere near exhausting the resources dwelling within them. There are deep wells of strength that are never used.

– Richard E. Byrd, Arctic explorer.

FACT #74

The World's Flattest Floor

Marshall engineers developed the world's flattest floor, a special surface on which test items gliding on air bearings can simulate the movement of spacecraft in Earth orbit.

Quote:

A static hero is a public liability.
Progress grows out of motion.

– Richard E. Byrd.

FACT #75

RBCC: A New Propulsion Idea

One of NASA's newest initiatives, managed at the Marshall Space Flight Center, is the Rocket Based Combined Cycle (BRCC) concept, which uses a combination of jet and rocket power to achieve single stage to orbit capability. BRCC will allow a single stage spacecraft to take off from Earth, achieve Earth orbit, and return to land.

Quote:

It is not the mountain we conquer
but ourselves.

– Sir Edmund Hillary, leader of the first successful mission to the top of Mount Everest.

FACT #76

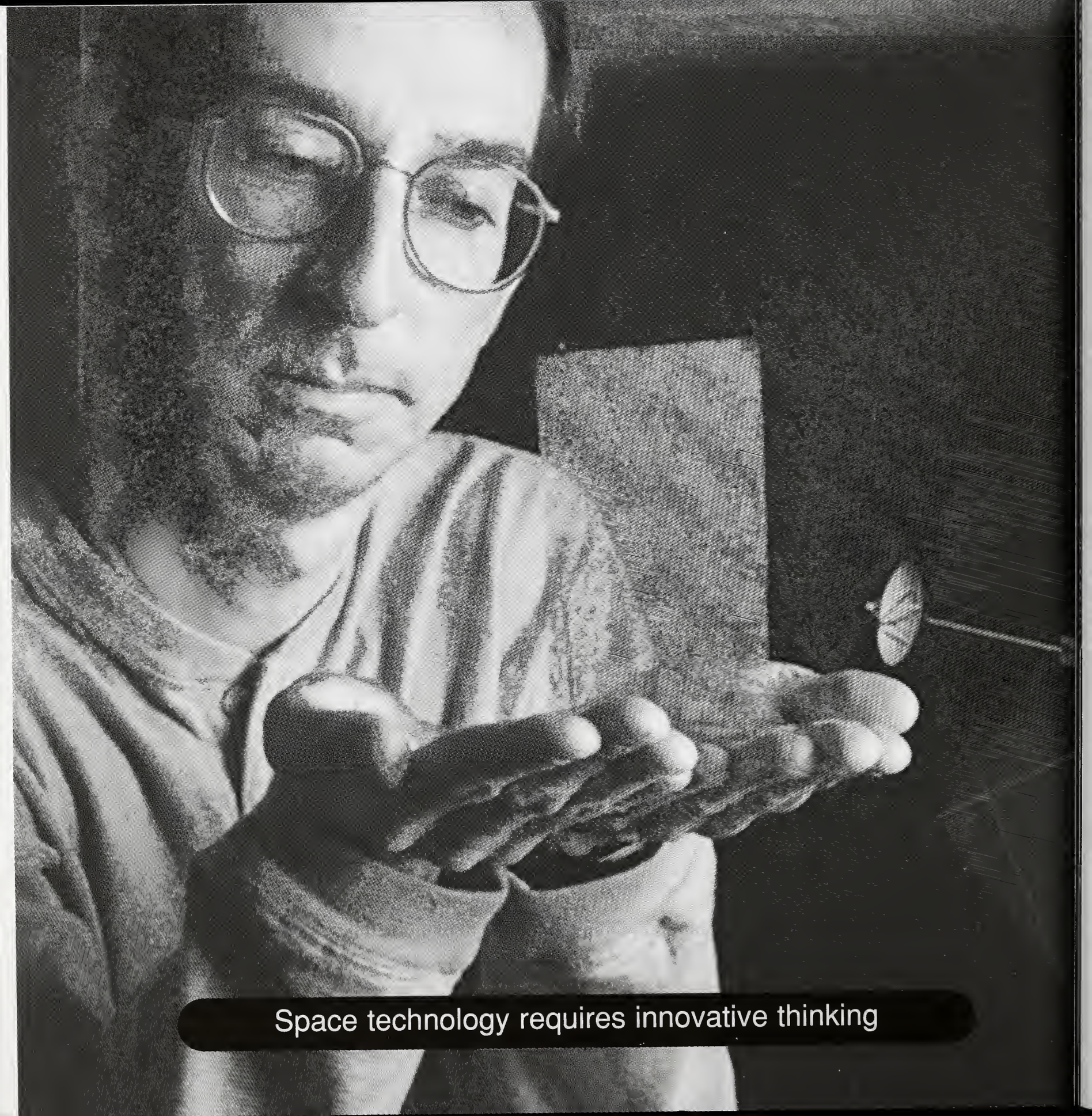
The Tether Idea

Marshall developed the Tethered Satellite System, which uses a tether stretched between two satellites to demonstrate the ability to generate electric power by flying through the earth's magnetic field.

Quote:

Problems look mighty small
from 150 miles up.

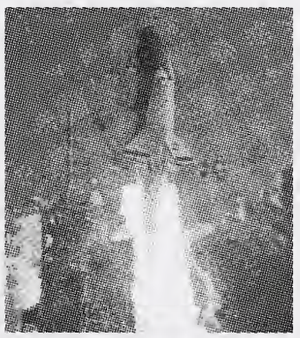
– Roger B. Chaffee.


Space technology requires innovative thinking

CHAPTER FOUR

NASA Technology Changes Our Lives

Many people are not aware of all the technological spinoffs from America's space program. NASA has documented more than 1,300 such applications, and more than 100 are from the space shuttle program alone. Here are 25, including several with medical applications.



FACT #77

Robotic Paint Stripping

A robotic paint stripping device developed through cooperation between NASA and Carnegie Mellon University removes paint from ships without releasing toxic airborne dust into the environment. Using a high-pressure water jet, it can blast away the old paint right down to the steel much faster and more efficiently than older systems.

Quote:

Only a life lived for others is a life worth living.

– Albert Einstein.

FACT #78

Space Age Water Purification

The International Space Station required a very lightweight, energy-efficient water purification system. Using the principle of reverse osmosis, a private firm in Oregon developed such a system for NASA, which is at work on the space station. The firm has found other uses for its system, such as modifying it to remove leachate from landfills, thus protecting groundwater.

Quote:

When a man does all he can, though it succeeds not well, blame not him that did it.

– George Washington.

FACT #79

GIS Helps Farmers

NASA has added tremendously to our knowledge of Planet Earth. Using global imaging satellite (GIS) technology, a North Dakota firm delivers NASA satellite images of Earth over the Internet. Farmers can use these images and the data associated with them to improve crop yields through more precise farming techniques.

Quote:

The reward for work well done is the opportunity to do more.

– Jonas Salk, developer of the vaccine for polio.

FACT #80

JPL Software Aids Business

Special software developed by NASA's Jet Propulsion Laboratory and the California Institute of Technology to assist in high-speed data transfer for space shuttle missions has been adapted by a California firm to integrate work-flow processes much faster than any previous software. The software lets large organizations with multiple locations improve their efficiency and workflow.

Quote:

It is good to realize that if love and peace can prevail on earth, and if we can teach our children to honor nature's gifts, the joys and beauties of the outdoors will be here forever.

– Jimmy Carter.

FACT #81

NASA Develops Software Agents

A new type of software developed by NASA's Goddard Space Flight Center, in cooperation with a San Diego, California, firm, employs software "agents," software components that will perform certain tasks automatically, which allows software developers to work faster. The product will allow software developers with no experience using intelligent agent technology to more easily build new software applications.

Quote:

Our greatest happiness does not depend on the condition of life in which chance has placed us, but is always the result of a good conscience, good health, occupation, and freedom in all just pursuits.

– Thomas Jefferson, third U.S. president.

FACT #82

Software Predicts Component Aging

Software developed by NASA's Glenn Research Center and a small private firm in Long Beach, California, for use in predicting the strength, durability, and reliability of space flight components may soon find numerous private applications. The software could be used to predict aging of museum artifacts, computer chips, and even sporting goods equipment.

Quote:

Whenever you do a thing, act as if all the world were watching.

– Thomas Jefferson.

FACT #83

System Monitors Remote Locations

Though it may seem impossible to be in more than one place at a time, a real-time monitoring system developed at the Kennedy Space Center allows NASA to access space shuttle and ground support equipment from any desktop computer with a Web browser. A variation of the system allows monitoring of remote sensors around the world from one location, and is being used extensively in manufacturing and the medical fields.

Quote:

Try not to be a person of success,
but rather a person of virtue.

– Albert Einstein.

FACT #84

Robotic Arm Aids Surgeons

Operating rooms are stepping into the twenty-first century as the result of a NASA-developed robotic arm that can assist surgeons in endoscopic surgery using non-invasive techniques. NASA developed a device called AESOP (Automated Endoscopic System for Optimal Positioning) to service space shuttle payloads and satellites. Today surgeons can use AESOP to control the motion of endoscopic surgical cameras, resulting in a steadier view of the operation and more accurate surgeries.

Quote:

To deal with individual human needs at the everyday level can be noble sometimes.

– Jimmy Carter.

FACT #85

Myomonitor Aids Muscle Tone Studies

NASA has extensively studied the effects of microgravity on the muscular performance of astronauts. A device known as the myomonitor, developed by NASA and a private firm in Boston, provides a new dimension in the field of electromyography, the electronic study of muscle toning. The myomonitor, which can be worn by a subject to monitor muscle activity, has applications in sports medicine, workplace injury prevention, ergonomics, and muscle training.

Quote:

Honesty is the first chapter
in the book of wisdom.

– Thomas Jefferson.

FACT #86

BIOSCAN HELPS DETECT BREAST CANCER

Breast cancer is a major medical problem, and as many as one in nine women may develop it during their lifetimes. Early detection is key to survival, and a new device for early detection has been developed using technology developed at NASA's Jet Propulsion Laboratory. Called the BioScan system, the device can detect breast cancer by detecting its ability to secure a new blood supply.

Quote:

Do what you can to show you care about other people, and you will make our world a better place.

– Rosalynn Carter, U.S. first lady.

FACT #87

Vibration Detection System

Prior to space shuttle launches, NASA monitors payloads for vibration and movement. The technology for such monitoring has been developed into a tri-axial data acquisition system that acquires, stores, and analyzes vibration data during transport. Called G-Logger, it has tremendous data storage capacity and can be used in industry, for applications such as automobile suspension checking and crash detection.

Quote:

We build too many walls and not enough bridges.

– Sir Isaac Newton.

FACT #88

Flare Deactivates Land Mines

It is estimated that as many as 120 million unexploded land mines are scattered throughout the world, a danger to millions of people. But the Thiokol Corporation, makers of the solid rocket fuel for the space shuttle, has developed a "demining flare" using surplus propellant. The device works by burning through a land mine's outer casing to neutralize the explosives inside. It is being used in Jordan and Kosovo to deactivate thousands of land mines left over from previous conflicts.

Quote:

Example is not the main thing in influencing others. It is the only thing.

– Albert Schweitzer, explorer and humanitarian.

FACT #89

Shuttle Escape Hatch Helps Arthritis Victims

People with severe arthritis have difficulty standing up after being seated. A retired NASA engineer who helped develop an emergency escape device for workers at Kennedy Space Center launch pads used the apparatus as the basis for a device to help people with arthritis stand from a seated position. The lightweight device is portable and easy to use, and has met with wide acceptance.

Quote:

How far you go in life depends on your being tender with the young, compassionate with the aged, sympathetic with the striving, and tolerant of the weak and strong. Because someday in your life you will have been all of these.

– George Washington Carver,
American scientist.

FACT #90

Space Suits: Beating the Heat

NASA developed space suits that astronauts wear on space walks, where temperatures can vary from hundreds of degrees near absolute zero. Today variations of these suits are used by racing drivers, shipyard workers, and others who have to work in areas of intense heat.

Quote:

All truths are easy to understand once they are discovered; the point is to discover them.

– Galileo.

FACT #91

Cardiac Pacemakers Use Telemetry

Cardiac pacemakers used today rely heavily on NASA developed telemetry technology. Telemetry, or signal sending and detecting capability, is critical to NASA space missions and has been improved upon considerably since the early 1970s. Modern pacemakers also rely on NASA-developed long-life batteries.

Quote:

Let me tell you the secret that has led me to my goal. My strength lies solely in my tenacity.

– Louis Pasteur, chemist and inventor of pasteurization process.

FACT #92

Cordless Power Tools First Developed for Space

Early in the shuttle program, NASA developed cordless power tools for astronauts to use in doing repairs in space. Some of today's popular cordless power tools rely on batteries and control devices used in the space program.

Quote:

If I have a thousand ideas and only one turns out to be good, I am satisfied.

– Alfred Nobel, Swedish scientist, inventor, and businessman who endowed the Nobel prizes.

FACT #93

Breathing Device for Firefighters

Self-contained breathing devices developed for astronauts have been modified for use on Earth. Today firefighters use lighter, smaller, self-contained breathing devices that rely on super-cold air heated by the human body in backpacks less than six inches thick. These compact air systems provide firefighters more than 30 minutes of breathing time.

Quote:

Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has.

– Margaret Mead, anthropologist.

FACT #94

Heart Pumps: Fuel Pump Technology

Technology used in spacecraft fuel pumps has been modified for use in a ventricular heart pump for heart patients. The tiny pump is less than two inches long, weighs less than four ounces, and is currently undergoing clinical trials.

Quote:

Imagination is more important than knowledge.

– Albert Einstein.

FACT #95

Insulin Pumps: NASA Technology

Treatment of diabetics requires that insulin be administered to patients in precise amounts and at a controlled rate. The technology developed by NASA for the biological laboratory on the Mars Viking spacecraft has furnished the basis for both external and implantable insulin pumps that are lightweight and extremely reliable.

Quote:

Only aim to do your duty, and mankind will give you credit where you fail.

– Thomas Jefferson.

FACT #96

LEDs: Chemotherapy for Kids

For the Spacelab missions of the mid-1980s, NASA developed special light-emitting diodes (LEDs) for use in plant growth experiments. Today doctors at the Medical College of the Wisconsin in Milwaukee are using similar LEDs in a form of chemotherapy treatment to kill cancerous cells in children having brain tumors.

Quote:

You have to have confidence in your ability, and then be tough enough to follow through.

– Rosalynn Carter.

FACT #97

Skylab Water Purifiers at Home

During the Skylab program of the early 1970s, NASA developed methods of water purification and reuse for astronauts. Today these same methods have been adapted for use in community water systems to kill bacteria, viruses, and algae. Homeowners use this technology in faucet filters popularly used to take lead and other minerals out of tap water.

Quote:

Associate yourself with people of good quality, for it is better to be alone than in bad company.

– Booker T. Washington, African-American educator and leader.

FACT #98

Telemetry for Ingestible Thermometers

NASA-developed telemetry used for communication with satellites is today being used in several ways. A medical application is an ingestible thermometer that can be swallowed and will relay deep internal body temperatures to an external receiver.

Quote:

Chance favors the prepared mind.

– Louis Pasteur.

FACT #99

Velcro: NASA Technology

A commonly used fastener in garments, Velcro was the result of NASA's need for a quick fastener for spacesuits that did not use buttons, zippers, or other more common fastening techniques.

Quote:

You cannot teach a man anything; you can only help him discover it in himself.

– Galileo.

FACT #100

Lasers to Fight Heart Disease

Heart surgeons now have a powerful new weapon in the fight against heart disease, one of the top killers in the U.S. A laser system developed for use in satellite-based atmospheric studies is being used to treat the buildup of fatty deposits, called plaque, in arteries. The device vaporizes these deposits without damaging artery walls.

Quote:

There is a single light of science, and to brighten it anywhere is to brighten it everywhere.

– Isaac Asimov, scientist and science fiction writer.

FACT #101

Monitoring System for Stroke Patients

For the ongoing space shuttle program, NASA monitors the equilibrium of astronauts as they return from orbit. Modified versions of these devices are now widely used in the medical field to treat patients suffering from dizziness, stroke, and chronic dizziness.

Quote:

Whether we travel in a jet transport or in a spacecraft, we still look down, or back to life, on the crowded surface of the earth as both our source and our destination.

– Charles Lindbergh.

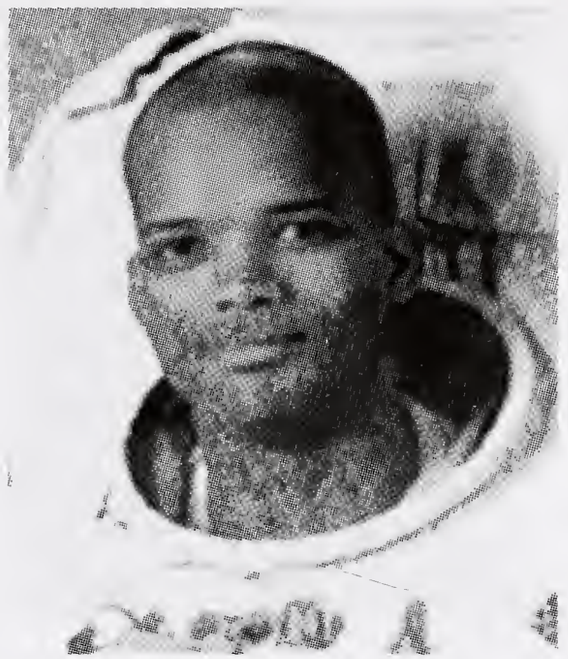
Oakwood College students involved in research project

African-American Space Explorers

As of August 2002,
the six African-American
astronauts in the
Astronaut Corps included:

YVONNE D. CAGLE
(Colonel, USAF)

Selected by NASA in April 1996, she reported to the Johnson Space Center in August 1996. Currently, Dr. Cagle is assigned technical duties in the Astronaut Office Operations Planning Branch, supporting the Shuttle and the space station.



ROBERT L. CURBEAM, JR.
(Commander, USN)

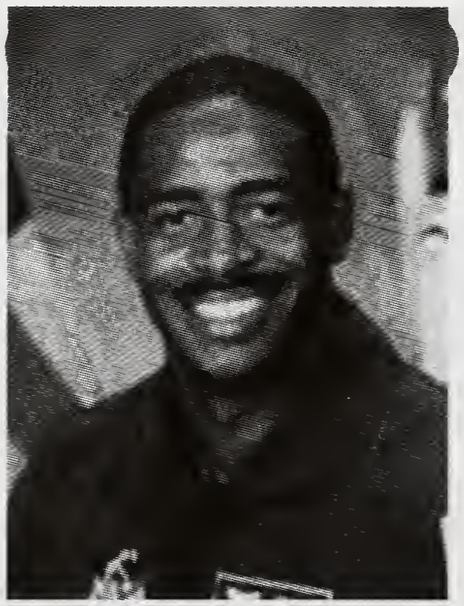
Selected by NASA in December 1994, he reported to the Johnson Space Center in March 1995. He is a veteran of two space flights, STS-85 in 1997 and STS-98 in 2001, and has logged over 593 hours in space, including over 19 EVA hours during three spacewalks. Between these two flights, he served as a spacecraft communicator (CAPCOM). After his second flight, he also served as a CAPCOM branch chief.

B. Alvin Drew
(Lieutenant Colonel, USAF)

Selected as a mission specialist by NASA in July 2000, he reported for training in August 2000. He will serve in technical assignments until assigned to a space flight.

JOAN E. HIGGINBOTHAM

Selected as an astronaut candidate by NASA in April 1996, she reported to the Johnson Space Center in August 1996, and has been assigned technical duties in the Payloads and Hibitability Branch, the Shuttle Avionics and Integration Laboratory. Currently, she is assigned technical duties in the Astronaut Office CAPCOM (Spacecraft Communicator) Branch. She is qualified for flight assignment as a mission specialist.



LELAND D. MELVIN

Leland began working in the Fiber Optic Sensors group of the Nondestructive Evaluation Sciences Branch at NASA Langley Research Center in 1989. In 1994 he was selected to lead the Vehicle Health Monitoring (VHM) team for the cooperative Lockheed/NASA X-33 Reuseable Launch Vehicle (RLV) program. He reported for training in August 1998 and is currently assigned to the Astronaut Office Space Station Operations Branch. He will serve in technical assignments until assigned to a space flight.

Stephanie D. Wilson

Selected by NASA for the Astronaut Corps in April 1996, Stephanie Wilson reported to the Johnson Space Center in August 1996. She is qualified for flight assignment as a mission specialist. Initially assigned technical duties in the Astronaut Office Space Station Operations Branch, Wilson is currently assigned to the Astronaut Office CAPCOM Branch, working in Mission Control as prime communicator with on-orbit crews.

So You Want to be an Astronaut?

Types of Astronauts

- **Pilot Astronaut:** military trained test pilots who fly the shuttle to and from orbit.

- **Mission Specialist:** scientists and engineers who operate and handle the shuttle's science payloads, the robot arm, and the spacesuits.

- **Payload Specialist:** an expert chosen by NASA to fly when his/her expertise is needed on an experiment.

Requirements to Be a Mission Specialist Candidate

- A bachelor's degree in engineering, biological sciences, physical science, or mathematics.
- Following your degree, three years of professional experience.
- An advanced degree can take the place of experience (master's, one year, doctoral, 3 years..
- Be able to pass a NASA class II space physical.
- Height: between 58 and 76 inches (4'8" and 6'3").

Requirements to Be a Pilot Astronaut Candidate

- A bachelor's degree in engineering, biological sciences, physical science, or mathematics.
- Three years of professional experience.
- At least 1,000 hours of pilot-in-command time experience.
- Be able to pass a NASA class I space physical.
- Height between 64 and 76 inches (5'3" and 6'3").

For a Well-Grounded Career

Potential occupations for those who would prefer to keep their feet on the ground:

Scientists
Astronomer
Biologist
Chemist
Geologist
Medical Doctor
Meteorologist
Nutritionist
Oceanographer
Physicist
Physiologist
Psychologist
Veterinarian

Engineers
Aeronautical
Aerospace/Astronautics
Biomedical
Chemical
Civil
Computer
Electrical
Environmental
Industrial
Materials
Mechanical
Nuclear
Petroleum
Plastics
Safety
Systems

Mathematicians
Computer Scientist
Mathematician
Statistician
Systems Analyst

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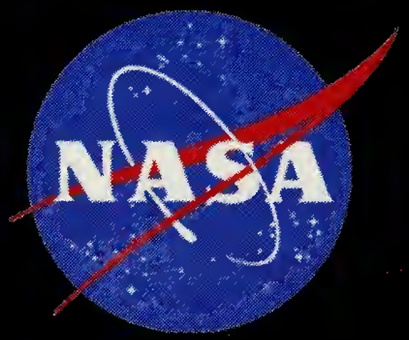
NOTES



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